

Seattle Public Utilities

Natural Drainage Systems (NDS)
Maintenance Manual

Revision Date: December 2007

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I. Overview

This chart is a summary of *routine* maintenance activities for the design of Natural Drainage System (NDS) Projects. Several *non-routine* maintenance activities are also included within this chart.

This chart is intended to be a Maintenance Manual for scheduling and performing maintenance activities. The manual features images and descriptions for vegetation, hardscape, infrastructure, and infiltration rates. It includes NDS sites used currently in Seattle and several images from NDS projects in other municipalities. It is important to realize that *no single project includes every design element*. (That is, all the NDS portrayed in this chart will *NOT* be found within a given NDS project.) Maintenance crew coordinators need to use the relevant maintenance categories for a given project per the NDS Service Agreement.

This manual is divided into four service levels for the vegetation section and three service levels for the hardscape and Infrastructure section. For some design elements, the service levels are very similar.

II. How to Use This Manual

The successful use of this manual hinges on the inspection of project features, which in turn triggers the appropriate maintenance activities. To use this chart first select the desired Service Level for maintenance on an existing NDS project, then maintenance crews will inspect the system for the conditions listed in the left-hand column of the chart. Note that the desired service level may vary from project to project, based on the NDS goals, the project location, the project age (i.e. whether or not the plants have successfully established), and economic considerations. The descriptions and images for each service level may be used to help determine by visual inspection whether recommended maintenance activities, in the right-hand column, will need to be performed.

III. Contacts

Name	Phone Number	Title
Drena Donofrio	206-571-1566	NDS O&M Asset Manager
Deb Heiden	206-386-1802	Urban Ecosystems Asset Manager
Tracy Tackett	206-386-0052	LID Program Manager

Table I. Landscape Manual

Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service D (Poor Effort)
Aesthetics (vegetation and trash)	<ul style="list-style-type: none"> Planted vegetation is healthy, dense, and attractive Little or no weeds are present Clean, distinct edges Mulch is evenly distributed & deep enough No bare spots No evidence of erosion (stabilized surfaces) At least 80% survival of establishing plants Limited shoulder compaction Plant palette is working for facility Homeowner is fully maintaining (where applicable) 	<ul style="list-style-type: none"> Planted vegetation is mostly healthy with a generally good appearance Small quantities of weeds are present Loose edges: grass encroaching on swale or vice versa, plant hanging onto street/sidewalk Some mulch is present Occasional bare spots Erosion likely unless maintenance improved Some shoulder compaction Plant palette is mostly working for facility Homeowner is providing some maintenance (where applicable) Able to achieve Level A without complete retrofit 	<ul style="list-style-type: none"> Poor Planted vegetation health and appearance Weeds common No edges; surrounding vegetation spills into swale or vice versa Mulch is absent Bare spots are frequent Substantial eroded areas Shoulder compaction Plant palette is not working for facility Homeowner is not maintaining swale (where applicable) Unable to achieve higher service levels without complete retrofit 	<ul style="list-style-type: none"> Poor Planted vegetation health and appearance Weeds dominant No edges; surrounding vegetation spills into swale or vice versa Mulch is absent Bare spots are common Substantial eroded areas Shoulder compaction Plant palette has failed Homeowner is not maintaining swale (where applicable) Unable to achieve higher service levels without complete retrofit
Special Considerations for Noxious Weeds	Zero tolerance of Class A, B, C and non-designated noxious weeds	Zero tolerance of Class A and B. Class C weeds are controlled or absent. Non-designated weeds are controlled or absent.	Zero tolerance of Class A weeds. Class B and C are controlled. Non-designated are present (Control Prog. Is minimal)	Zero tolerance of Class A weeds. Class B, C, and Non-Designated are largely uncontrolled except for public safety reasons (illegal dumping, obstructs vision)
	<p style="text-align: center;"><u>King County Noxious Weed List</u></p>			

Planted vegetation coverage, health and appearance

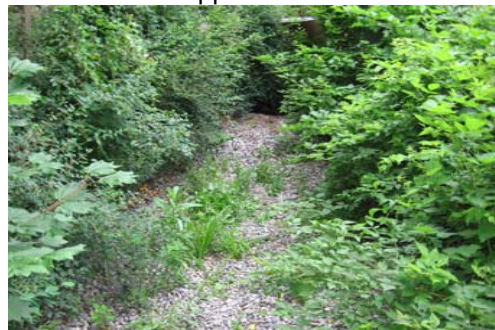
Lush vegetation; excellent appearance



Mostly healthy vegetation with good appearance



Mostly healthy vegetation with neglected appearance



Poorly planted vegetation health and neglected appearance



Healthy, well-maintained vegetation; excellent appearance



Appearance is good



Moderate appearance



Poorly maintained appearance



<p>Organic matter (mulch layer), edges, shoulder compaction</p>	<p>Deep mulch layer, clean edges, limited compaction</p> 	<p>Some mulch, loose edges, some compaction</p> 	<p>Little mulch, no defined edge, shoulder compaction</p> 	<p>No mulch, no defined edge, shoulder compaction</p> 
<p>Presence of weeds</p>	<p>No weedy species present</p> 	<p>Occasional weedy species</p> 	<p>Lots of Weedy species</p> 	<p>Weedy species predominant</p> 

Erosion and bare spots

No erosion or bare spots



Some erosion and bare spots



Substantial erosion and bare spots











Completely eroded and bare spots



Table II. System Functionality

Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Poor Effort)
SYSTEM FUNCTIONALITY				
Bioretention (vegetation & soils/substrate)	<ul style="list-style-type: none"> • At least 80% of swale bottom is covered with healthy, wetland vegetation • Soil is well aerated, no evidence of vehicle compaction • No erosion, channelization or scouring • Water drains within 24 hours • Minimal bare spots • Acceptable level of sediment or debris accumulation 	<ul style="list-style-type: none"> • Between 60-80% of swale bottom is covered with healthy, wetland vegetation • Some evidence of vehicle compaction (lack of mulch) • Some erosion, channelization or scouring • Most water drains within 24 hours, minimal long-term ponding • A few bare spots • Acceptable level of sediment or debris accumulation 	<ul style="list-style-type: none"> • Between 40-60% of swale bottom is covered with healthy, wetland vegetation • Compacted soils • Erosion, channelization or scouring • The presence of long-term ponding (> 72 hours) • Many bare spots • Significant build up of sediment or debris 	<ul style="list-style-type: none"> • Less than 40% of swale bottom is covered with healthy, wetland vegetation • Compacted soils • Erosion, channelization or scouring • The presence of long-term ponding (> 72 hours) • Many bare spots • Significant build up of sediment or debris
Biofiltration (vegetation & soils/substrate)	<ul style="list-style-type: none"> • At least 80% of swale bottom covered with healthy, uniformed fine-stemmed vegetation at least 18 - 24 inches high • No erosion, channelization or scouring • No ponding • Minimal bare spots • Acceptable level of sediment of debris accumulation 	<ul style="list-style-type: none"> • Between 60-80% of swale bottom covered with healthy, uniformed fine-stemmed vegetation at least 18 - 24 inches high • Some erosion, channelization or scouring • No ponding • A few bare spots • Acceptable level of sediment or debris accumulation 	<ul style="list-style-type: none"> • Between 60-40% of swale bottom covered with healthy, uniformed fine-stemmed vegetation, of at least 18 -24 inches high • Erosion, channelization or scouring • The presence of ponding • Many bare spots • Significant build up of sediment or debris 	<ul style="list-style-type: none"> • Less than 40% of swale bottom covered with healthy, uniformed fine-stemmed vegetation, of at least 18 -24 inches high • Erosion, channelization or scouring • The presence of ponding • Many bare spots • Significant build up of sediment or debris
Bioretention + biofiltration (vegetation & soils/substrate)	<ul style="list-style-type: none"> • At least 80% of swale bottom is covered with healthy, uniformed fine-stemmed wetland vegetation at least 18 - 24 inches high • Soil is well aerated, no evidence of vehicle compaction 	<ul style="list-style-type: none"> • Between 50-80% of swale bottom is covered with healthy, uniformed fine-stemmed wetland vegetation at least 18 - 24 inches high • Some evidence of vehicle compaction (lack of mulch) 	<ul style="list-style-type: none"> • Less than 20-50% of swale bottom is covered with healthy, uniformed fine-stemmed wetland vegetation at least 18 - 24 inches high • Compacted soils • Erosion, channelization or scouring 	<ul style="list-style-type: none"> • Less than 20% of swale bottom is covered with healthy, uniformed fine-stemmed wetland vegetation at least 18 - 24 inches high • Compacted soils • Erosion, channelization or

Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Poor Effort)
	<ul style="list-style-type: none"> No erosion, channelization or scouring Water drains within 24 hours Minimal bare spots Acceptable level of sediment or debris accumulation 	<ul style="list-style-type: none"> Some erosion, channelization or scouring Most water drains within 24 hours, minimal long-term ponding A few bare spots Acceptable level of sediment or debris accumulation 	<ul style="list-style-type: none"> The presence of long-term ponding (> 72 hours) Many bare spots Significant build up of sediment or debris 	<ul style="list-style-type: none"> scouring The presence of long-term ponding (> 72 hours) Many bare spots or noxious weeds/grass Significant build up of sediment or debris
Swale bottom vegetation				
Sediment or debris accumulation				
Conveyance	<ul style="list-style-type: none"> Healthy vegetation 	<ul style="list-style-type: none"> Mostly healthy vegetation 	<ul style="list-style-type: none"> Some vegetation 	<ul style="list-style-type: none"> Poor or no vegetation














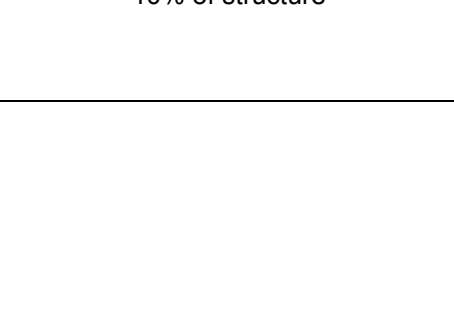
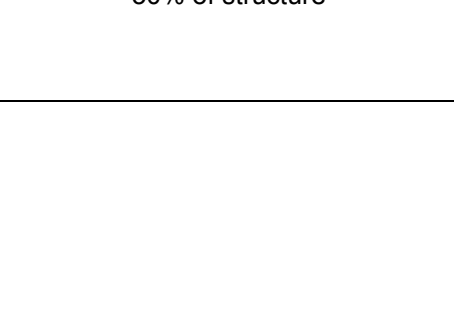
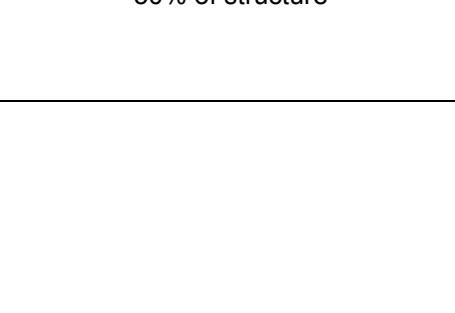












Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Poor Effort)
(vegetation & soils/substrate)	<ul style="list-style-type: none"> • No erosion, channelization or scouring • Minimal bare spots • No build up of sediment or debris • No non-designed obstructions to flow 	<ul style="list-style-type: none"> • Some erosion, channelization or scouring • A few bare spots • Some build up of sediment or debris • Minimal non-designed obstructions to flow (over-grown vegetation, trash rack blockages) 	<ul style="list-style-type: none"> • Erosion, channelization or scouring • Many bare spots • Significant build up of sediment or debris • Significant non-designed obstructions to flow (over-grown vegetation, trash rack blockage) 	<ul style="list-style-type: none"> • Erosion, channelization or scouring • Many bare spots • Significant build up of sediment or debris • Significant non-designed obstructions to flow (over-grown vegetation, trash rack blockage)
				

Table III. Hardscape Manual

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
HARDSCAPE & INFRA-STRUCTURE	Summary <ul style="list-style-type: none">• sediment is minimal• infrastructure is always accessible• no competition between roots and pipes• no trash is present• small accumulation of organic debris on grates or screens• limited buildup of sediment behind check dams or log weirs• no erosion or undercutting surrounding weir walls• rockery and walls are stable and secure• stormwater sedimentation structures less than ½ full (NPDES)	Summary <ul style="list-style-type: none">• some sediment is present• infrastructure is usually accessible• some competition between roots and pipes• small amounts of trash are present• moderate accumulation of organic debris on grates or screens• occasional large sediment deposits behind check dams or log weirs• minimal erosion and/or undercutting surrounding weir walls• occasional loose rocks; walls are secure• stormwater sedimentation structures less than ½ full (NPDES)	Summary <ul style="list-style-type: none">• Lots of sediment buildup is observed• infrastructure is mostly inaccessible• significant competition between roots and pipes• Trash is present• Heavy accumulations of organic debris on grates or screens• frequent large sediment deposits behind check dams or log weirs• Erosion and/or undercutting surrounding weir walls• Loose rocks; walls are not secure• stormwater sedimentation structures less than ½ full (NPDES)	
<input type="checkbox"/> Sedimentation structures— TYPE 2	<p>Sediment is blocking 10% of structure</p> 	<p>Sediment is blocking 30% of structure</p> 	<p>Sediment is blocking 50% of structure</p> 	<div><input type="checkbox"/> if sediment present, remove trash and unwanted organic debris</div> <div><input type="checkbox"/> muck out / vacuor structure and dispose of waste properly</div>

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
<input type="checkbox"/> Grates and debris screens on catch basins (CBs)	Accumulation of organic debris covers 10% of structure 	Accumulation of organic debris covers 30% of structure 	Accumulation of organic debris covers 50% of structure 	<input type="checkbox"/> if present, muck out / vacuum catch basins and dispose of waste properly. Clear debris and vegetation growth around intakes.
<input type="checkbox"/> Outlet structures—TYPE 2	Accumulation of organic debris covers 10% of structure 	Accumulation of organic debris covers 30% of structure 	Accumulation of organic debris covers 50% of structure 	<input type="checkbox"/> Remove debris and dispose of waste properly
Flow control structures and overflow structures or pipes	Accumulation of organic debris covers 10% of structure 	Accumulation of organic debris covers 30% of structure 	Accumulation of organic debris covers 50% of structure 	<input type="checkbox"/> remove debris and vegetation growth and dispose of waste properly

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
				
<input type="checkbox"/> Log weirs and check dams	<p>Sediment deposit of check dams or log weirs is about 10%</p> 	<p>Sediment deposits of check dams or log weirs is about 30%</p> 	<p>Sediment deposits of check dams or log weirs is about 50% or more</p> 	<input type="checkbox"/> add splash-pool (rocks) to reduce scouring of swale-bottom for undercutting or eroding <input type="checkbox"/> remove sediment, debris, and trash if ponding upstream of check-dam
<input type="checkbox"/> Weir walls w/ flow control notch	<p>Sediment deposit downstream of check dams or log weirs is about 10%</p>	<p>Sediment deposit downstream of check dams or log weirs is about 30%</p>	<p>Sediment deposit downstream of check dams or log weirs is about 50% or more</p>	<input type="checkbox"/> add rocks to splash-pool to prevent scouring <input type="checkbox"/> reinforce weir wall (<i>non-routine</i>) if leakage occurs at structure edges

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
				
<input type="checkbox"/> Rockery / boulders PHOTOS TO BE UPDATED (shown here with little vegetative cover, but rocks may become covered in plant growth in well- established projects)	10% of rocks or walls are unsecured 	30% of rocks or walls are unsecured 	50% of rocks or walls are unsecured 	<input type="checkbox"/> ensure large rocks and boulders are stable
Manufactured block sidewalls	10% of rocks or walls are unsecured	30% of rocks or walls are unsecured	50% of rocks or walls are unsecured	<input type="checkbox"/> ensure blocks and bricks are stable
















Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
				
Soil-wrap walls ("green walls")	<p>Erosion or undercutting of 10% is walls visible around rockery, walls and weirs</p> 	<p>Erosion or undercutting of 30% is visible around rockery, walls and weirs</p> 	<p>Erosion or undercutting of 50% is walls visible around rockery, walls and weirs</p> 	<p>□ repair as needed stabilize loose soil-bricks, notify vegetation crew if weeds present, water needed, or re-planting required</p>

Table III. Other Elements

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
OTHER ELEMENTS	<ul style="list-style-type: none"> • up to 10% blockage caused by organic matter, sediment, debris or trash • irrigation system functions properly with no blockages or breaks in drip system • ponding only to intended depth (varies by location) • pond capacity is maintained • no liner leakages reported 	<ul style="list-style-type: none"> • between 10-30% blockage caused by organic matter, sediment, debris or trash • irrigation system functions properly with no blockages or breaks in drip system • ponding only to intended depth (varies by location) • some sediment may reduce pond capacity • no liner leakages reported 	<ul style="list-style-type: none"> • more than 30% blockage caused by organic matter, sediment, debris or trash • irrigation system has occasional blockages or breaks in drip lines • ponding only to intended depth (varies by location) • sediment buildup causes reduced pond capacity • no leakages reported 	
<input type="checkbox"/> Curb cuts	<p>Curb is up to 10% blocked</p> 	<p>Curb is between 10-40% blocked</p> 	<p>Curb is above 40% blocked</p> 	<input type="checkbox"/> remove trash and organic debris and dispose properly
<input type="checkbox"/> Culverts	<p>Culvert is up to 10% blocked</p>	<p>Culvert is between 10-40% blocked</p>	<p>Culvert is more than 40% blocked</p>	<input type="checkbox"/> remove trash and organic debris and dispose properly

Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
				
<input type="checkbox"/> Irrigation systems (for establishing vegetation)	holes in drip irrigation correspond with plant locations; nozzles have no breaks, leaks, or blocks 	plants and drip holes mostly aligned; minimal seeping of water when system is off; no breaks or blockages 	system has breaks or leaks; vegetation is not being adequately watered; complaints of ponding 	<input type="checkbox"/> repair as needed (for establishing vegetation 0-3 years old)
<input type="checkbox"/> Porous/pervious pavers	water infiltrates well, pavers are up to 10% clogged or minimal ponding is observed	water infiltrates well, pavers are between 10-40% clogged and minimal ponding is observed	water does not infiltrate well, pavers are more than 40% clogged	<input type="checkbox"/> vacuum debris







Service Category	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)	Recommended Maintenance Activities
	 A photograph showing a well-maintained garden bed with a pattern of dark grey interlocking pavers. Small, square, light-colored decorative stones are embedded in the pavers. In the bottom left corner, there is a small cluster of green foliage and bright orange flowers.	 A photograph showing a garden bed with a pattern of dark grey interlocking pavers. Small, square, light-colored decorative stones are embedded in the pavers. In the bottom left corner, there is a small cluster of green foliage and bright orange flowers.	 A photograph showing a garden bed with a pattern of dark grey interlocking pavers. Small, square, light-colored decorative stones are embedded in the pavers. In the bottom left corner, there is a small cluster of green foliage and bright orange flowers.	

Table IV. Infiltration

Infiltration Failure	Any evidence of a cell holding water for more than 24 hours needs to be reported to USM LID/NDS O&M Asset Manager for monitoring or retrofitting. Contact: Drena Donofrio at 206-571-1566
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Table VI. Safety, Spill Prevention and Response, and Pest Control

Service Category	Service Level A (Excellent Effort)	Service Level B (Good Effort)	Service Level C (Moderate Effort)	Service Level D (Low Effort)
SAFETY, MOBILITY, ACCESS	<ul style="list-style-type: none">• Vegetation causes no visibility (line of sight) or driver safety issues• Infrastructure is always accessible• Vegetation around infrastructure is maintained at height to prevent damage during routine maintenance	<ul style="list-style-type: none">• Vegetation causes minimal visibility (line of sight) or driver safety issues• Infrastructure is mostly accessible• Most vegetation around infrastructure is maintained at height to prevent damage during routine maintenance	<ul style="list-style-type: none">• Vegetation causes visibility (line of sight) or driver safety issues• Infrastructure is not accessible• Vegetation around infrastructure is will be damaged during routine maintenance	<ul style="list-style-type: none">• Vegetation causes visibility (line of sight) or driver safety issues• Infrastructure is not accessible• Vegetation around infrastructure is will be damaged during routine maintenance
				
SPILL PREVENTION	<ul style="list-style-type: none">• Exercise spill prevention measures whenever handling or storing potential contaminants.			
SPILL RESPONSE	<ul style="list-style-type: none">• Clean up spills as soon as possible to prevent contamination of stormwater.			

PEST CONTROL	<p>Insects:</p> <ul style="list-style-type: none">• Standing water remains in the basin for time periods suitable to insect development.• Identify the cause of the standing water and take appropriate actions to address the problem. <p>Rodents:</p> <ul style="list-style-type: none">• Rodent holes are present near the facility.• Fill and compact soil around the holes.
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